



NASA Advisory Council (NAC) Aeronautics Committee

July 30, 2013
NASA Headquarters, Washington, DC
Aeronautics Research Mission Directorate (ARMD)

Summary of Meeting Minutes

Participants:

First	Last	Organization	Role
Marion	Blakey	AIA	Chair
John	Borghese	Rockwell Collins	Member
Mark	Anderson	Boeing Phantom Works	Member
Michael	Bragg	University of Illinois	Member
J.P.	Clarke	Georgia Tech	Member
Mike	Francis	UTRC	Member
Ilan	Kroo	Stanford University	Member
Tom	Wood	Bell Helicopter	Member
Gen. Lester	Lyles	NAS ASEB	Member, Ex-officio
David	Vos	Independent Consultant	Member
Michael	Maloney	Nat. Research Council	Observer
Jaiwon	Shin	ARMD	NASA AA
Susan	Minor	ARMD	Exec. Secretary
John	Cavolowsky	ARMD	ASP Director
Doug	Rohn	ARMD	AvSP Director
Jay	Dryer	ARMD	FAP Director
Jon	Montgomery	ARMD	IMO Director
Ed	Waggoner	ARMD	ISRP Director
Cathy	Bahm	ARMD	ISRP Dep. Director
Lee	Olsen	NASA	FAA Liaison
Fred	McKee		
Edward	Goldstein	AIA	Observer
Alan	Angleman	NRC	Observer
James	Schultz	ARMD	Recorder

Morning Session

Introductions

Ms. Marion Blakey called the Aeronautics Committee meeting to order at 9:07 a.m. and welcomed members and participants, including those on the phone.

FY2014 ARMD Budget Status by Jaiwon Shin

Dr. Jaiwon Shin welcomed members and said that he appreciated the time they spent to attend. Going into August, with two months to go in FY13, NASA still doesn't have a budget. NASA's Aeronautics Research Mission Directorate (ARMD) is operating at \$533 million, a reduction from \$570 million. ARMD's long-term strategy will be to align its portfolio in six research areas. Two new areas are Unmanned Aerial Systems (UAS) integration into the National Airspace System (NAS) and composite materials. The reason for the additions is to reflect near-term activities; they encompass more and are broader, with a far-reaching thrust. Dr. Shin said that ARMD has been trying to strengthen relevance in helping U.S. industry, directly impacting and contributing to economic growth to help to create jobs.

A discussion about rotary-wing research ensued and what the future of that research may be. ARMD isn't doing anything dramatically different, but is looking into what could be done better. Dr. John-Paul Clarke pointed out that the U.S. Army science board has identified shortcomings in Army rotorcraft going forward. Dr. Shin replied that it wasn't just the Army, but the fact that the commercial rotorcraft industry has also fallen behind the Europeans. ARMD has been working closely with the Army; helping U.S. industry should also benefit the Army. Another aspect of future research is converging, emerging capabilities like autonomy, electric propulsion and intelligent systems. The hope is to open up new opportunities that commercial interests may be able to capitalize on. Jay Dryer and his team have been working on that.

Gen. Lester Lyles said that the Defense Science Board was about to publish a study on major technologies that the Department of Defense (DoD) needs to invest in to maintain military superiority, including rotary technology. Dr. Shin said that it was great to hear that: "It's a really exciting area, these converging technologies. That's the type of research NASA should be conducting."

Dr. Shin said that beyond the FY2013 budget, all numbers in the out years are notional. Dr. Mike Francis asked that if the budget is set at \$533 million, what's the expectation it will bump back up? Dr. Shin replied he would address that, citing the FY2014 appropriations comparison. There is a \$1.5 billion difference in NASA's Aeronautics budget request in the House versus the Senate. If the sequester doesn't change, the out-years budget will be a lot less. If the country stays on a continuing resolution (CR), there is a possibility for an even lower budget.

Dr. Shin did say he was "elated" that because the House-Senate figures almost match. The Senate side has always been more challenging because it's so focused on space. There's been no haggling over the direction in which ARMD has been heading. The House did call for a restoration of about \$16 or \$17 million to hypersonics. Otherwise, it

has been pretty much a blanket endorsement, and a good testimony about collective success. One comment from the House budget briefing in the March time frame came from a member who said, “Every time I hear your briefing I wonder why we can’t give you more money.’ And they did, about \$300,000 more, which is very encouraging.”

In response to a question from Mr. John Borghese, Dr. Shin said that additional cuts would result in a delay in the advanced composites project in FY 2014. The difficulty is that the duration of the CR has been getting longer and longer. The agency continues to prepare for multiple scenarios.

Ms. Blakey said that she was under the impression that the administration had zeroed out education funding. Was she mistaken? Dr. Shin said that no, she was not. Congress is trying to restore those monies. However, discretionary educational activities might go away, to the tune of \$70 million.

In response to a question from Ms. Blakey about hypersonics and an ensuing discussion about collaboration between DoD and NASA, and a potential involvement with the Defense Advanced Research Projects Agency (DARPA), Dr. Shin said that Jay Dryer’s Fundamental Aeronautics Program (FAP) has been working diligently on this, and that ARMD wants to make sure some level of hypersonics research continues at NASA.

Mr. Dryer pointed out that in terms of hypersonics research, ARMD still has about \$5 million the directorate is investing, notably in tests in the 8-Foot High Temperature Tunnel. He cited the National Partnership for Aeronautics Testing’s work and involvement, and how DoD is stepping up work on the high-speed technology demonstrator. NASA is looking at what work DoD needs to do in NASA wind tunnels, and is in the process of specifying what should be done in NASA facilities with NASA personnel. All activity will be done under a reimbursable basis.

In response to a question from Gen. Lyles about what will happen if DoD continues under the sequester, and the fear that science and technology will take the biggest hit, Mr. Dryer responded that ARMD is not sure what will take the biggest hit. The assumption is that wind tunnel research would scale back to the barest minimum. Mr. Mark Anderson said that there remains a strong interest in hypersonics at DoD, specifically at DARPA. There’s a unique role for NASA to play, and there may be opportunities for NASA to reengage going forward. Dr. Shin said that ARMD will keep at, and not get completely out of, hypersonics research.

Dr. Shin said that funding for the new composites project will remain level at \$25 million for the next five years, and will require heavy partnership with industry and the Federal Aviation Administration (FAA). In discussing the Roundtable that occurred on June 18, Dr. Shin said that ARMD’s strategy was well-received. In terms of the best practices for conducting aeronautics research and development, Dr. Shin said he took very seriously the observation that ARMD should encourage risk and enforce turnover in [its research] portfolio. Dr. Shin said that ARMD needs to keep the excitement going and phase out [any research] that isn’t working: “We really need to bring back that culture of a high turnover rate ... How do we bring back that X-plane kind of excitement? I want to bring that back to NASA Aeronautics.”

Dr. Shin remains concerned about engaging the future generation so that young people will come to work in aerospace careers. He cited the example of how career opportunities at SpaceX have been exciting younger career people. NASA has the materials to do the same thing, but execution remains a challenge.

In response to a question from Dr. David Vos about the challenges involved in bringing back the X-plane culture, and the barriers to its implementation, Dr. Shin said that NASA has become risk-averse and has lost a little bit of that kind of “try as we go” attitude. Too often, NASA studies return with a technology testbed that is complicated and costly. A mindset change is needed: “Sometimes you have to go back to the future.”

Gen. Lyles asked from where the change should originate, asserting that someone has to be the catalyst. Dr. Shin replied that NASA Aeronautics certainly wants to be the catalyst. To that end, ARMD has assembled a body such as the NAC Aeronautics Committee to actively make suggestions and generate ideas. Dr. Shin pointed to a groundswell of activity, especially as regards roundtable discussions.

Dr. Vos said that there has not been credibility being given to the unmanned systems market. Citing the cost of sensing and computing, he pointed out that communities and universities could put together packages to leverage new technology. The buzz existing around that marketplace is what NASA should leverage, based on real business opportunities. Dr. Vos cited SpaceX as a great example, in particular the way the company is leveraging automation and autonomy.

Dr. Clarke observed that the unmanned activity is not only at the vehicle level. He believes NASA has missed an opportunity to be the place where unmanned system technologies like swarming can be tried out. In response, Dr. Mike Francis observed that it's not just what is done, but how it's done. Failure must be accepted; one cannot drive out all the risk: “If you're ready to take the incremental failures you then can prepare for ultimate success.” Dr. Shin agreed, saying that to fail early and rapidly demonstrate feasibility are two things that come to mind.

Mr. Anderson suggested spending time with SpaceX to learn what they are doing. He advised to directly ask SpaceX employees why they're working for the company. ARMD may want to form its own startup and then insulate it from the overall aeronautics enterprise. A general discussion then ensued about getting things done and demonstrating feasibility.

Mr. Anderson asserted that “The nation needs you to go fly stuff, and you need to do it every 36 months. ARMD is the place to do it.” Mr. Borghese observed that DoD is a lot more conservative than NASA is when it comes to flight testing. He believes that NASA must recapture excitement regarding its work. Composites research, while very valuable, won't excite young people. Dr. Shin replied that ARMD was mindful of that and that it was a matter of balance. In response to a question from Gen. Lyles about an ARMD X Prize, Dr. Shin replied that ARMD doesn't at the moment, but that an overhaul of the external seedling investment is underway. Dr. Shin would like to increase that investment funding to \$10 million annually. To that end, ARMD has been asking discipline-based questions, and what can be done to address big problems.

ARMD Flight Research Approaches and Plans by Susan Minor

In response to a mention of the UAS-NAS Automatic Dependent Surveillance-Broadcast (ADS-B) flight test, Dr. Ed Waggoner said it was key for two reasons: It was a distributed environment and was a first step. Mr. Borghese mentioned the Live Virtual Constructive-Distributed Environment (LVC-DE) and integration.

Elaborating on the Alternative Fuel Effects on Contrails and Cruise Emissions (ACCESS) flight experiment, Mr. Dryer said that NASA took the lead, working closely with the FAA and the international community that helped in coordination with international partners. There are plans to leverage what NASA has done. It is a two-phase flight experiment; ARMD is now preparing for a second phase.

In response to details about G-III Subsonic Aircraft Testbed (SCRAT) development, Gen. Lyles asked if ARMD is involved in a partnership with Gulfstream. Dr. Shin replied that ARMD partnered with the Air Force Research Laboratory (AFRL). As the effort expands, other industrial partners may be involved. Dr. Waggoner mentioned the noise-reduction efforts with Gulfstream involving the Environmentally Responsible Aviation (ERA) Project. In response to a query from Dr. Francis about why that airplane was chosen, Dr. Waggoner replied that he didn't know, but that he would obtain an answer. Dr. Shin said that if one looks at NASA flying assets, there are a lot of military aircraft but not many civil aircraft: "That gets to one of the challenges we have."

Extended discussion involving Dr. Francis, Mr. Anderson and Ms. Blakey about the cost and composition of the NASA flight test fleet. Any new X-plane initiative can't properly succeed unless the flight-research program is looked at. Dr. Shin said that ARMD is not going to play the role of "a hammer looking for nails" anymore. He wants to open up horizons and become more open and smarter. There was a mention of the logistical difficulties of involving airplanes in composites research. Dr. Vos asserted that having an aircraft inventory is not the point: "You don't need to fund the hungry mouths of existing facilities [and assets]."

Dr. Francis observed that unmanned aircraft have limited access to atmospheric wind tunnels. Mr. Borghese said that there are certain facilities that only exist at NASA. If NASA doesn't do it, no one else will. NASA can outsource much of this. A key question is how will ARMD maximize what it does given the present infrastructure.

In response to a description of the Boeing ecoDemonstrator Program, Ms. Blakey asked what was NASA's role vis-a-vis Boeing. Ms. Minor replied that ARMD is a customer. Boeing will ask for proposals to fly this particular technology. Only if the proposer is present when the primary operator is ready to go will the flight take place.

A discussion ensued about Boeing searching for a major anchor tenant. Other experiments are allowed. There may be NASA experiments on the tail [of the experiment aircraft]. Real hardware can be modified. There will be an evolution of both Boeing and NASA's participation. Although it will not be an ongoing effort annually, it should be mutually beneficial and cost-effective.

In response to question from Ms. Blakey about the ecoDemonstrator tour, Mr. Anderson said he believed Boeing would say that the D.C. visit was a spectacular success. He added that, to a real extent, it is a marketing and communications campaign.

A discussion ensued about shared missions and FAA involvement. More observations were made, included the present discounted state of the business-jet market, and the opportunity to conduct flight testing with airplanes people haven't already seen. Dr. Ilan Kroo said that SpaceX is an example of where one can do actual testing of feasible vehicles.

In response to the mention of the Air Traffic Management (ATM) Technology Demonstration (ATD)-1, Mr. Borghese said that, without the recession, the general public would be suffering through enormous flight delays at airports. The ability to add additional aircraft to the NAS must come with substantial change to NAS; otherwise, delays will worsen. Mr. Borghese said he was surprised results are so little with ATD-1. Dr. Vos said that it would be enormously beneficial for the public to see that NASA and the FAA are well-synchronized. He was likewise not impressed with ATD-1. Dr. Clarke cited fuel-burn numbers and the ways they're calculated, and said that the key takeaway is that there are savings to be had.

Ms. Blakey mentioned public awareness and marketing as being key. The FAA tends to "put its light under a bushel." She would love to see more focused NextGen information put out by NASA. Dr. Shin said that ARMD will double up its effort. He cited previous guidance from the committee on the need for fuel savings research.

In response to a mention of the High Ice Water Content (Ice Crystal) Engine Icing Flight Campaign, Mr. Doug Rohn said that the Aviation Safety Program has modified a key probe so it can fly on a platform a European team had already developed, with flights scheduled for January and February 2014. They are beyond the initial team and are piggybacking, with NASA and the FAA both paying for extra flight hours.

Report on UAS Subcommittee by David Vos

Dr. Vos said that it was a very good forum and a good experience. The subcommittee wanted to provide objective feedback and relevance of activities, and to take a look at how well collaboration was occurring. They will focus on things going on, driven by the FAA. The topics were autonomy, automation and integration into the airspace, with the potential of tremendous benefits.

A discussion ensued regarding of subcommittee members' professional experience and expertise. Mr. Borghese said that it was very good information they have developed as a team and asked where the information is going. To NASA? Dr. Vos said that, in a few slides to come, the overall committee would see the activities that came about. They were tailored to the questions that had been asked and are aligned into the work packages.

Dr. Vos said that it is one of the few such committees where there has been significant public participation. The industry is behind the curve in disseminating information. In citing an upcoming UAV industry show in D.C., he said committee members "will be amazed what's going on there. It's an exciting future for aviation." There are a lot of

companies that believe their activities are constrained by [getting certified]. Infrastructure and rules-making issues are still to be resolved. In response to a question from Ms. Blakey about the demographic makeup of the industry show, whether attendees would be mostly students, or whether there would be across-the-board attendance, Dr. Vos replied that it would be across the board: a broad spectrum. Dr. Francis said the entire D.C. Conference Center will be taken up by the UAV conference.

In response to the UAS in the NAS Phase 2 portfolio selection overview, the key decision point (KDP) schedule overview, and presentation of the Implementation Plan milestone with UAS-NAS contributions, Mr. Borghese said that some areas weren't being addressed. Dr. Kroo said that was for the FAA, mostly. Dr. Vos said that what was being represented were the key activities going on in the overall business. Within the NextGen concept, collision and avoidance is a key topic. Until that's addressed, operation in the NAS will be very constrained. There is a need to decide on the rules and subscribe to those rules; otherwise, accidents will occur. The growth of traffic density must be enabled. The subcommittee thought there was not enough recognition of that problem, as was command and control. Where it ended up was a program to which was attached a significant amount of money.

In response to the presentation of NASA's UAS-NAS technical focus areas and the Phase 2 content decision process, Dr. Francis asked if the subcommittee looked at the different phases of flight. Dr. Vos said that from their perspective there was no phase fundamentally unimportant enough to ignore: "You need to give the big, the whole answer in terms of what needs to be matured."

Commenting on the proposed Phase 2 portfolio, Dr. Waggoner said that the FAA certified the airplanes, which was "a tremendous step." It was an aircraft certification with its unmanned capability on board. Dr. Vos discussed the airframe and operational aspects, all of which need to be covered and addressed. The process must be structured into accomplishable steps. In response to Ms. Blakey's query about whether it would be the aerial platform and not the connectivity, Dr. Vos said he didn't know. Dr. Waggoner said that he thought the the ground station hadn't yet been certified.

Dr. Vos said they were very focused that that kind of support to the activities [iterated on the current slide] actually occur. They didn't want to reinvent what's already been done; rather, piggyback on what's established. Dr. Vos continued with an extended iteration of work packages, and a discussion ensued about Phase 2 being in the budget. No final decision has yet been made on what will stay in the budget through 2016. A reassessment is currently underway.

Some items – especially the satcom category – are not in the proposed Phase 2 portfolio, although the work packages are comprehensive and all-encompassing. The subcommittee strongly supports Phase 2 going forward. There are total work packages (TWPs) to support and top TWPs to de-emphasize, but not necessarily eliminate. In response, Dr. Francis observed that it was important to recognize two needs for spectrum: humans in the airplane for the situational awareness that provides, and the spectrum that those who operate a payload want. Dr. Vos said it was "definitely non-payload stuff." Dr. Francis said that communications is probably the fastest-moving train; what is being done now is not going to be done in the future. Nevertheless, NASA needs to be involved.

Dr. Vos said that the program team knew that. There may be tremendous progress in the personal-communications world, but there are significant challenges in the high-reliability command-and-control world. It obviously needs to evolve over time. The subcommittee was trying to be pragmatic about what it takes to get into the marketplace. There is a need to go way beyond analog radio. Small UAS may be one of the business domains that develops quickly, and NASA ARMD needs to be the leader in this domain.

In response to the subcommittee's summary, findings and observations, Ms. Blakey said that she was "incredibly impressed with the amount of detail you took on." She had no idea of the amount of complexity involved, and wanted to very much thank the subcommittee. Dr. Vos said that they were "all geeks, so it was fun for us."

Mr. Borghese observed that in order to have autonomy, what will be required are very complex systems that do what humans do manually. Dr. Vos replied that it would be very important at the outset to pick the best cost-effective solution. It needs to be kept simple and tractable. As soon as it evolves to the point where no one understands what's going on, it's a problem. Things can be structured such that they are tractable. Autonomy really means automated. Effective solutions are ones dependent on the operational environment, and hierarchical levels of automation that do the right thing. It's about finding the best practical solution. Significantly impressive things can be accomplished without having to address artificial intelligence, and problems can be addressed with current capabilities.

Dr. Francis agreed, and pointed out that much of the problem is deterministic but untouched. Moving into the mission domain means dealing with a different level. Like the cellphone, [autonomous] technology will advance regardless. Autonomy is the ability to do the complete decision cycle: "It is in front of us right now and NASA should be tackling it even as we speak." Dr. Vos said there is a near-term opportunity to do something that's really tractable.

A discussion ensued about experience-based learning and reaction. Machines aren't there yet. The "distant future" might well be five years from now. The FAA must think differently, and it is really important to pick the battles. Nevertheless, everyone should be respectful about what the FAA does and is mandated to do, and be aware of what the FAA's daily lives are. The auto industry is going to drive autonomy into their vehicles: That will be the template that will get FAA certification.

Afternoon Session

Ms. Blakey called the afternoon session to order: "Part of our purpose is to consider the discussions and our feedback to the administrator. We may want to consider UAS [for that]."

National Research Council (NRC) Committee on Autonomy Research for Civil Aviation: Overview and First Meeting Summary by Michael Francis

Dr. Francis said the NRC Committee will have four public meetings over the next six months, and would like to get input to assist the study group. In response to a question

from Gen. Lyles about underwater autonomous vehicles, Dr. Francis said yes, they were looking at underwater as well, including the whole mobile robotics community. In response to a question from Mr. Borghese about looking to other countries for unique knowledge or expertise, Dr. Francis said they were looking at that. To some extent it's an artifact of the computer revolution. The NRC Committee probably has more speakers on the list than can possibly be accommodated. His question to the Aeronautics Committee is whether the NRC Committee is covering something too heavily or if there's something else that needs consideration. Dr. Francis is not clear what the chemistry of the participants will be. Such groups tend to develop over time.

Mr. Borghese asked whether the final report will be focused on NASA. In response, Dr. Francis said no; it will focus on a national research agenda and which agencies should do what. It will be a national agenda because the topic is too broad. How it is handled will be the topic of additional discussion.

Mr. Borghese observed that NRC Committee membership doesn't include any panelists from DoD or the automotive industry. Dr. Francis replied that although they did not have an automotive industry representative as such, the study team is diverse and, eventually, one or two should join. Dr. Clarke said the NRC Committee will hear from Google about the automotive side. The Committee is determined not to miss things at the system level rather than just focusing on individual solutions.

Dr. Francis said the NRC Committee won't solve the problem. They will bring the agenda to solve the problem. The group will look into the crystal ball as best it can, with outcomes focused on civil aviation and long-term national issues.

A discussion ensued about learning about what's being done in other arenas, not necessarily to solve a specific problem: What are the outliers to worry about and the things not to worry about? It could be a piece of technology or an architecture. As examples, look at the autonomy on cars or on agricultural farming equipment; there are a different set of requirements and rules. Safety-critical software must be developed. Lessons can be learned from what's already being developed to see what might be useful.

Mr. Borghese observed that the list of participants are user-oriented, versus experts in automation in other areas, like autos and/or farm equipment. Dr. Francis said that was a fair observation. When he first saw the list, Dr. Francis wondered why they didn't have a perception expert. But they can come to the meetings in any case. Michael Maloney said the NRC Committee is addressing some of the concerns prior to the August meeting. There is a long list of people the Committee expects to interact with. Dr. Francis said that trying to make an incursion to get folks from the automotive community is challenging because it's so highly competitive.

Dr. Vos said that the word "research" in the participants slide shows up way too often. It would be much more useful to have people who need to figure out how to get the money and then create something with it. Dr. Francis said that there aren't but a couple of folks who deal with small UAS. There isn't quite as much representation there. Until deliberations and discussions begin, it's not clear what is present and what is needed.

Gen. Lyles said that the Aeronautics and Space Engineering Board (ASEB) addressed that topic with not enough industry being included. The ASEB recognizes just what Dr. Vos said as an issue.

A discussion then ensued about the crew in the cockpit and autonomy. Certification is a huge issue; there are not perfect communications at any point. Dr. Vos said that autonomy pertains to what level of automation is on board and how it relates to any human pilots on board. The philosophy of automation has not yet evolved to the point where if something goes wrong automation can help the crew where there is a failure of human control.

Mr. Borghese said that, to him, that's human factors. How do you make the system so intuitive that the pilot doesn't make mistakes, as in the case of Air France Flight 447? Dr. Francis replied that the group is looking at the problem in both dimensions. Dr. Vos said that oftentimes the certification requirements are what drive the human being who is the ultimate adjudicator. One needs to think about certification as well as philosophy. Dr. Francis said that the change in rules won't happen overnight; the group recognizes that.

Gen Lyles said that the undersea community – the Navy in particular – but even the oil and gas communities have remotely operated underwater vehicles (ROVs) in which they're investing. Gen. Lyles added that the Navy is doing a lot in architecture and some of that will likely be of interest: "I particularly commend the Navy in the special programs office. You might want to contact Battelle; I can give you the points of contact."

Mr. Borghese said he was very concerned about building something that is cyber-resistant. Someone ought to focus on that area. Sensors are also undergoing a revolution, in particular imaging sensors for the automotive industry. Dr. Vos urged inclusion of people who build real, fielded solutions. Currently that's significantly missing. Mr. Anderson agreed, saying that "You need to bring in those kinds of people to put a stake in the ground and say, 'We're going to build this thing.'" The inclusion of the Jet Propulsion Laboratory is positive because of their execution of long-term projects. There's a too-heavy academic focus on the team; there needs to be a "dirt-under-the-fingernails perspective."

Dr. Kroo said there's a bigger-picture system perspective. Dr. Francis said that was expressing a system-of-systems point of view. Dr. Kroo added that one of the things he and his colleagues have been thinking of is helicopter fatalities when a rotorcraft flies into wires.

Advanced Composites Project Planning Overview by Richard Young

Dr. Young presented the problem statement, pointed to increased testing, and the building-block approach for structural certification. There are challenges for accelerating composites development and certification, and he rhetorically wondered why industry has yet to address those challenges.

Mr. Borghese asked how large are the users developing the material. Dr. Young replied that the project would be focusing on Boeing, Lockheed, GE and Pratt Whitney. Dr. Vos asked if they were talking about primary structures. Dr. Young replied that yes, mostly

large primary structures.

In terms of this new initiative, NASA is uniquely suited to lead and contribute, considering its technical expertise and the fact that it is a trusted entity. Mr. Young described how the project focus was determined. Twenty-eight companies in eight different sectors were invited for feedback during a workshop, and high-payoff technical focus areas were suggested. The project will be looking for leveraging opportunities, and coordinating plans with other entities already engaged in such work. A national roadmap for composite certification involving DoD, the FAA and NASA has been developed.

NASA is only doing design and certification research; actual manufacturing will be up to others. A strong partnership with the FAA and industry has been established from the beginning. The only way to do this effectively is through a government-industry consortium as a public-private partnership.

Mr. Borghese observed that the project's timeline has work concluding in 2018. He wondered that, as materials change over that time period, shouldn't the project also be looking at where industry is going with these new materials? And doesn't Dr. Young think carbon structures will be around in five years? Dr. Young replied that that was what people brought forward. There will be new materials; part of this is showing a process that works, and not changing all the parameters at once. Ceramic matrix composites are a different process; maturation will have to occur there.

Mr. Borghese asked about additive manufacturing and the availability of tools to analyze the materials. Dr. Young said he did think they will be applicable to that. Dr. Francis said he assumed the project would include the integration of structures as part of the focus. Dr. Young said that yes, they are anticipating bonded structures will predominate.

Mr. Wood said that when one validates a tool, it's necessary to know what it looks like on the inside. He asked where the validation will come from. Dr. Young said that non-destructive investigation (NDI) is dispersed throughout this process and is applied throughout.

A discussion about the quality and composition of materials ensued. Variability does cost a buyer. Quality will be improved with analysis. Dr. Young cited technical challenges, including efficient design and enhanced manufacturing. In response to a question from Dr. Vos about the improvement numbers being accurate enough to meet project goals, Dr. Young said that, at the moment, the point is to accelerate [advanced composites development]. Dr. Vos wondered whether a 30% [improvement] is meaningful to industry. Dr. Young said yes, it is.

Mr. Borghese observed that the project is doing five separate things, each related, each lasting five years. If the project could do this in a year, it would be a big deal. In five years, the industry will have moved on. Can the project do tools in less time than that? Dr. Young said there needs to be early return on investment. As the project strengthens its connection with industry, areas of very short-term effort will be identified. There will be an evolution and identification of low-hanging fruit; the project will demonstrate its benefit in the first two years.

A discussion ensued about percentages of improvement. In terms of fuel-burn reductions, even small ones have a dramatic impact. No one yet knows the limits of what can be accomplished. Perhaps the [reduction amounts] need to be higher. Mr. Anderson said that although he knew when this all started, he was surprised where it ended up. A lot of NASA's money is going to go into this activity. The game is played at the billions-of-dollars level by Boeing. NASA's investment here isn't really significant. However, if the project "finds a problem, you will really crush. You have to find a niche where you can have a significant impact."

Mr. Wood likened the project's work to early fatigue research in metals. The process has to begin somewhere; a seedling in the ground. This kind of research is necessary for progress to be made [in delivering next-generation airplanes]. It's high-risk but high-reward work. Mr. Anderson said the technical challenge needs to be laminar shear. Something with the title "enhanced manufacturing" won't matter much.

A discussion ensued about language and calibrating the goal. There is a cost benefit and a revenue benefit. The risk is too high to pick up an incremental benefit. With full-cost matching at \$250 million, it would be prudent at the end of five years to say this is what has been bought. There is a concern that broad, sweeping titles don't convey the needed benefit. There is a need to continue to assess inputs and needs of industry.

Mr. Borghese said the project should try to show value much more quickly than five years. He asserted that if a company invested with [the project] to get a 30% improvement, that is not a big deal. It sounds too conservative. Maybe it's reducing tests down significantly.

A discussion followed about reordering the project's technical challenges. Mr. Borghese said that a look to the automotive industry would be in order, especially as regards building hybrid cars. Dr. Kroo said composites will change everything because of the automotive industry. The development of resins had been dormant for decades, until the automotive industry started investing just within the last year. NASA's involvement is positive, but the future requires a different [technical] investment strategy.

Dr. Francis wondered if there would be a way to use a NASA agreement to use proprietary industry methods. A value statement is needed; otherwise, the perception may be that the project may slow industry down. Dr. Vos cited sensors and low-cost accelerometers. The auto industry invested in both: they are inexpensive and extremely durable.

Dr. Clarke asked that, in regards to the certification component, does the project have confidence in composites going forward? A discussion then ensued about validating the results of fatigue tests. FAA certification requires a definitive point in time. There is an inspection for certain parts, and integrated vehicle health management (IVHM) will keep the parts on the airplane until it's time for them to come off. There's a benefit for having a common basis: outcomes can be shared on a general basis without getting into the details of a proprietary agreement.

Mr. Anderson urged the project to put the greatest amount of specificity on what the project is going to accomplish to advance the cause: "Don't revisit the sins of the past."

Look to the future, where NASA needs to be, and learn from these different efforts. Don't plow the same field." In response, Dr. Young offered his thanks and agreed, saying that he "need[s] to be more solid."

Mr. Anderson said he didn't think there would be any constraint. A focus on specific agreements would be better. The issue will be being sidelined into some eddy versus pioneering the path to the future. The project should be part of the latter. In response, Dr. Young said he didn't think the project would be pushed to the side. In conclusion, Dr. Young thanked the Committee for all their comments and their attention.

Committee Deliberations

Ms. Blakey began the Committee's deliberations by asking for any generalized comments and any specific observations about the ARMD budget. Mr. Borghese wished to commend Dr. Shin's budget presentation. ARMD should continue to do those things that attract young engineers to aerospace. Some of the things NASA does – X-planes – should be exciting ideas on the future. Dr. Francis said he echoed Mr. Borghese's comments, and added the observation that ARMD went from broader autonomy to UAS in the NAS. In response, Dr. Shin said that was the direction NASA received. Dr. Francis said that wasn't a bad thing at all.

Dr. Shin said that ARMD's six new thrust areas [in its strategic vision for Aeronautics] have been very enthusiastically accepted and supported [by upper NASA management]. Dr. Francis said that was the immediate need and it does fit. The way ARMD framed the NRC study is just fine.

Mr. Wood said he was glad ARMD was going to explore options to make the rotorcraft research more pertinent. Mr. Anderson said that what can be done about rotorcraft and hypersonic advances is very appealing. He said he fully agreed with Mr. Wood, and wished there was more money for the effort. Ms. Blakey added that, within NASA's budget, Aeronautics has been rock solid. This is not the nadir in terms of funding. She then inquired about flight research.

Mr. Borghese said that, relative to the ATM Technology Demonstration, these are very conservative goals. NASA should reach further and, to some extent, reward failure. Although NASA is making the NAS more efficient, a lot can be accomplished with a little money if done the right way. He cites Boeing's ecoDemonstrator project; NASA doesn't have to pay for the airplane. But: X-planes development is a necessity. The question is how ARMD becomes efficient on flight testing, and how it uses its budget to do so.

Dr. Francis observed that he used to carry a chart that shows what the pilot brings to the table as well as [the pilot's] liabilities. Although the pilot remains the key decisionmaker, the design space has just opened up. As examples, Dr. Francis cited micro-air vehicles and the number of G's [human operators] pull. There is also the ability to fly arbitrary orientations. There's a design space that has yet to be explored for X-planes. If ARMD is willing to marry the UAS with that set of potential benefits, it has a very interesting place to go with X-planes.

Mr. Anderson said he thought that was very sensible and very commonsense: "If we can go beyond the cake and get to the frosting, that's the X-planes. The nation needs to

do a \$250 million X- plane every two years. That's not yet in this program. That deal needs to be brokered."

Dr. Shin said that the ARMD presentation this morning was a baby step. From his personal view, ARMD spent upwards of \$30 million for two attempts that didn't pan out: One was the distributed roughness elements (DRE) experiment on the Gulfstream G-III aircraft and the [second was the] high ice water content. Neither worked for various reasons. He took away lessons learned from that: "We did force-feeding into the wrong platform; that's what we had and what we wanted to do. It took a long time to modify that thing. In the end, we couldn't do it." ARMD ran into all kinds of scheduling conflicts. They can't do it that way anymore.

In terms of DRE, Dr. Shin doubted that ARMD should have included "all the bells and whistles of all that instrumentation in one shot." He remains concerned about cost-effectiveness. ARMD's work should be "better and smarter," and should not have to take five or 10 years to conclude. He said that ARMD is bringing lessons learned into practice, and is committed to experiment. The X-plane [effort] should be used as a proxy. ARMD should return to the high-risk, can-do, gung-ho edge that NASA used to have. It's going to take some time, not just internally, but externally as well. It may not be entirely a resource-limited problem.

Dr. Clarke asked Dr. Shin how many tests need to be tested at scale in flight-test conditions: "Could you conduct them subscale? It's cheaper to build test items." Dr. Shin replied that at present, he didn't know. A cultural practice that ARMD needs to break is technology development that raises TRLs to a certain point to see if the technology works. Although that is appropriate in some instances, it is not for all. Dr. Shin said he is thinking about emulating the ecoDemonstrator practice of providing a platform and then asking what a potential collaborator would like to fly.

In response to a query from Ms. Blakey about the UAS capstone project, Dr. Waggoner said that it would be a hybrid. Three major integrated simulations/flight tests had been planned. A live constructive environment could be used for simulation in real traffic. Not only will the work involve integrated technologies in command and control, but there will also be a simulation with an unmanned aircraft in restricted airspace interoperating with other manned vehicles. As such, the project will demonstrate to the community and the FAA that these things will work. They are taking that kernel of an idea and integrating it into the plan. These technologies will be demonstrated in a safe environment, sometime in the late part of 2015 or the early part of 2016. The result should be obtaining data to hand off to validate minimum standards.

Mr. Anderson said he liked what Dr. Shin had to say about the DRE and high ice water content work. Depending on how one looks at those, one could be disappointed, but they could be blazing successes. They could be chapters one and two in [the future ARMD] X-plane book. He urged ARMD to "Go on to chapter three. I commend you." Dr. Shin said that ARMD researchers did a really good job of lessons learned.

Ms. Blakey cited the UAS presentation and recommendations, saying that the Committee can certainly affirm and take them on. They are very well thought out.

A discussion of Committee recommendations ensued, as well as one regarding small UAS. UAS are not well-instrumented. Because sensor technology and computer technology are coming down in cost, expense may become a non-issue. Larger UAS are the issue. A lot of small UAS (less than 55 pounds) have commercial potential in the short term, and are likely to become prolific because of lower cost.

Ms. Blakey then turned to the autonomy study. Dr. Francis said that speakers are coming out of those discussions. Dr Shin: "We have made [known] this Committee's desire to stay engaged with the study committee. Is this kind of engagement sufficient? Would you like to have some other kinds of engagement?" Ms. Blakey replied that she would welcome another discussion, and could devote a portion of the Committee's December meeting for that.

A discussion then occurred about a quadrotor, and two aircraft that have been certified. A suggestion from Dr. Clarke about whether sending out briefings would be a good idea elicited a response from Ms. Blakey that possibly a telecon would work, perhaps after the second meeting in August. A discussion also occurred about the NRC process and what was presented in an open session.

In commenting on Dr. Vos' presentation, Dr. Waggoner said that in the last two years there has been a convergence of philosophy and ideas. He was very grateful for the Committee's input, and believes what the overall [aviation] the community gets out of [the pending research] will be that much more valuable. Ms. Blakey thanked Dr. Waggoner for his expression of gratitude.

In an ensuing discussion about advanced composites, Mr. Borghese asserted that the project needs to show value before five years. An X-plane could be done [in that same period] for the money that will be spent. He said: "What would be more valuable? It will not be one of those things NASA is known for. You can see automobile companies doing a lot of this. They will be duplicating what is done here. Use NASA expertise to do other things."

Mr. Wood disagreed. Although he said he understood the need to get people excited, ARMD's composites project is a fundamental program: "It's not glitzy and it's not showy." Care should be taken in how fundamental research is treated. Mr. Wood suggested the project should rescale, with two or three promised outcomes, rather than five.

A discussion then ensued about ARMD and the project receiving the Committee's feedback. Ms. Blakey observed that, from the standpoint of industry, near-term goals with specific wins should be very good. Mr. Anderson wondered how the project ended up with ARMD's Integrated Systems Research Program (ISRP). He doesn't see how it fits. Dr. Shin said that may change; it's too early to say. He added that the comments made by the Committee have not just been valuable, but also timely. Dr. Shin believes the composites project-planning team will take those comments seriously. More may be presented and discussed at the Committee's December [2013] meeting. Ms. Blakey said that the greater the specificity of the goals, the better.

Dr. Young said the composites project could focus more on fundamentals or short-term impacts. One major focus would be to assemble technologies that have already been

developed and put them into practice, with the idea of working with people who are trying to apply them. Mr. Anderson said the Committee should be very leery of giving direction to the composites project: "You know more about this than all of us put together. We can give advice, but that's not direction. We don't need to be telling you what to do."

Mr. Wood encouraged continued FAA involvement: "You've got to have those guys on your team." Dr. Shin responded that ARMD will have that internal discussion, and give that advice consideration. Mr. Young described discussions about NASA working with industry and the FAA, and how the composites project was initially put in ISRP.

Ms. Blakey said that there is an urgent need with what NASA is being asked to tackle. Mr. Borghese said the Committee is just giving out ideas; ARMD knows what's best and what makes sense. Conservatism drives cost; perhaps the project could change the whole certification discussion. Dr. Young said that if they can bring industry into the overall discussion that will be an inherent benefit.

Ms. Blakey brought the Committee deliberations to a close.

Public Comments:

Fred McKey makes an additional comment on landing an unmanned aircraft at Reagan National Airport in Washington, D.C.

MEETING ADJOURNED at 5:21 p.m.
